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remains all winter in certain portions of Colorado finding abundant food, should migrate in spring, while a closely allied species, or variety, the chestnut-backed snowbird, appears just as the former is leaving, and occupies its place. That an insectivorous bird, as the wood pewee, for example, should delay its coming for a month or more after its cousin the phœbe, is explicable by the supposition that the two birds prefer different varieties of insects, and migrate only when they are to be found; but in the case of the granivorous birds, such an explanation is not admissible. It may, perhaps, be merely the force of habit; and such a theory is borne out by the fact that at distant points on the same isothermal lines, the different species do not, by any means, preserve the same order of coming. The water thrush and the towhee arrive two weeks earlier in central Iowa, than they do in northern New Jersey; the yellow-crowned warbler and two or three others on the other hand, are several days later; while most of the birds appear about the same time. But however that may be, whether future migrations will fully and completely reveal all the causes which influence the migrations of birds; or whether many of them are such as to baffle our researches, the subject loses none of its interest because we do not at present fully comprehend it, and must ever remain one of the most engaging studies in natural history.

ON THE STRUCTURE AND CASTING OF THE ANTLERS OF DEER.

BY JOHN DEAN CATON, LL. D.

MY investigations of the structure, system of nutriment, mode of growth, cause of death and rejection of the antlers of the *Cervidæ* have led to results which may interest the readers of the NATURALIST.

Notwithstanding Buffon insisted that the deer's antlers were vegetable products, like shrubs, grown upon the animal body, comparative anatomy has long since recognized the fact that they are bone. They are composed of the same constituents as other bones, but with a larger proportion of animal tissue, and as we shall presently see they are organized in the same way. They are anomalous bones, no doubt, and they differ in their economy from ordinary bone just so far and no farther, than these peculiarities require. They differ from all other bones in being entirely superficial. They are of very rapid growth, speedily mature, die and are soon thrown off, while all other bones are of very slow growth and persistent with the animal through life.

Like all other bones, for their growth and sustenance, they are provided with a *periosteum* with *Haversian canals* and *systems* and *medullary arteries.*

These external bones are grown upon a permanent process of the skull called *pedicels.* The periosteum of the antler, during its growth, together with a black cuticle covering it in which a coat of fine fur is inserted, is called the *velvet.* In this are a great multitude of large arteries which everywhere give off branches, which penetrate the growing antler and convey the blood to the Haversian canals, which are surrounded by, and connected with, Haversian systems, the same as in the long internal bones.

Besides this supply of nutriment from without an internal supply is provided for in two ways. First, a main artery, with a multitude of auxiliaries, passes up through the pedicel into the antler, which answers well to the medullary artery, and secondly a number of large arteries branch off from those of the periosteum at the end of the pedicel, and pass in through the articulation where the transitory unites with the permanent bone. These also pass up into the new-growing antler. Let any one take the first deer's head with horns which he finds in the market, and dissect away the skin at the butt of the antlers, and he will see with the naked eye the canals for these arteries passing into the articulation. The veins are mostly internal.

Thus understanding the system of blood-vessels provided for this external bone, and remembering that the blood-vessels are required to be, as they are, vastly larger than for internal bones, we are now prepared to follow its growth from the beginning to the end.

When the dead antler is cast off, which generally occurs with all but one of our American species in early winter, the blood-vessels of the periosteum reaching the butt of the antler are ruptured and a tolerably copious flow of blood from them ensues. They immediately set to work and extend the periosteum over the end of the pedicel, filling up the concavity in the top of the pedicel, constituting the seat of the new antler. It remains in this condition till spring arrives, when intense activity is observed in this covering, the temperature of which is greatly increased, and it becomes exceedingly sensitive like any other inflamed part. It is now observed to rise up appearing like a large blood blister, and the rudiments of the fur on the cuticle are observed. It rises up rapidly, forming within itself new systems of blood-vessels till it has attained a height of about twice its diameter, when an osseous deposit is commenced at the circumference of the top of the pedicel. Thus, is commenced the wall of the new antler which is now built up rapidly by new deposits, maintaining about the same distance from the upper end of the column, and very nearly of the full diameter of the perfected antler. As the wall rises it thickens very slowly, the upper extremity presenting a thin serrated edge. At first, the deposit presents the appearance of cancellated tissue, which is first filled up at the circumference and gradually resolved into Haversian canals and systems, which are supplied from the periosteum as before stated. If now we examine a specimen in its full career of new growth, say eight inches long, and one inch in diameter, we shall find the upper two inches a mass of highly inflamed blood-vessels, very sensitive to the touch, while below we can feel the established walls when the periosteum has become quite insensible. Let us dissect it and we find the cavity, large at the upper extremity, gradually narrowing to the lower end of the antler where it may be less than a quarter of an inch in diameter, but this opening does not terminate with the antler. It passes down into the pedicel where it may be a sixteenth of an inch in diameter, constituting the canal for the medullary artery. The whole internal portion of the pedicel is porous, admitting the passage of the other vessels through it into the growing antler above, passing through the cancellated tissue which has formed above till they reach the cavity where they unite with the vascular system, continually forming, as the new growth is extended upward. When a tine is to be thrown off, the beam widens and flattens and the member grows out from the shell, and thus the growth goes on, each progressing, in a proper ratio, so that the tip of each tine and snag is completed about the same time. By this time also the whole interior of the antler is filled with the cancellated tissue, solidified to a good degree towards the surface. The extremities are first completely solidified. Now occurs a phenomenon which does not occur with the internal bone whose conditions do not require it.

At the extremities first, the deposit of earthy salts goes on till this fills up the canals leading from the periosteum to the Haversian canals, so that the circulation through them is obstructed; and from these points complete condensation goes on till it reaches the lower extremity, when the communication between the external and the internal blood-vessels becomes completely severed. Now it is that the animal is prompted by some natural impulse to rub off this outer covering while yet it is gorged with blood. It comes off in long strips or shreds, which look like red cords suspended from the antlers and cover the animal with blood wherever they can reach and stain the trees and branches which he uses for the purpose. During this time the animal seems excited and even fierce. I *suppose* that this impulse to rub off the velvet arises from an irritation created in this thick vascular covering, from the fact that the arteries are pouring into it their full volume of blood, while the imperfect venous system with which it is provided is unable to return the blood sufficiently now that it is cut off from the veins within the antler which had principally performed that office before the surface canals had been closed.

While this has been progressing on the surface, the growth within has been progressing also from the nutriment received by the internal arteries. The cavities in the branches and the upper portion of the beam pretty soon become hardened, like ivory throughout, and the solid wall on the lower part much thickened. Before the central section has become solid, the nutrient vessels are obstructed below, and the deposit of bony particles is arrested while yet the larger portions of the antler are more or less porous, leaving what may represent the medullary canal, braced in every imaginable direction by thin plates of bone, constituting the walls of the cells, thus leaving the antler lighter, but nearly as strong as if it were entirely solid. The extent of this porous section and its density differ very much in different specimens; still it is present in all, to a greater or less extent. The active internal flow of the blood continues longer in young animals than in old, after the velvet is rubbed off. Sometimes the blood will flow appreciably when the antler is sawed off near its seat, two or three months after the velvet has been discarded, while in aged animals after that time, the *plasma* principally passes up into the antler.

In the meantime, the lower extremity of the antler, that convex part below the burr, which sits in the concave seat which is the top of the pedicel, has been solidifying much more rapidly than the internal portion above; and before the cells above had become too much filled up, the lower convex extremity, which, during the active growth of the antler, was traversed by the canals of all the internal blood-vessels leading to or from the antler, becomes more and more compact till finally these canals become completely filled up and the circulation above cut off. This lower crust now much resembles the articular bone terminating the internal bones at the articulations. It resembles it in its extreme solidity and larger granules, which any one can see on the roughened surface by inspecting any deer's antler which has been dropped from the living animal, for they are well exposed by the absorbent process to be presently described.

While nature has been doing this work another and a very anomalous work has been progressing in an internal bone.

The pedicel, which during the active growth of the antler was open and porous, allowing the internal blood-vessels to pass through it freely, so soon as the great demand for nutriment had ceased, commenced a new deposit of laminæ in those canals, which before the commencement of that new growth had been enlarged by absorption, until the blood-vessels passing through them are collapsed, and so the circulation through them arrested. This has become necessary in order to furnish a strong firm base for the antler while it is used as a weapon of warfare, which was not required during the growth of the antler, when the pedicel was spongy and weak. This annual destruction and reconstruction of bone tissue nowhere else occurs in the internal animal economy, and nowhere else do exigencies require it.

Now that all sources of nutriment, both external and internal, have been cut off from the antler, it dies and becomes a foreign body on the living animal, and as nature cannot tolerate this for a great length of time she has provided the means for discarding the inert body and presently sets those means in motion. One of the three systems of blood-vessels first described has not yet been destroyed. Those leading from the periosteum into the articulation still penetrate the seam although they cannot penetrate the solid crust now firmly united to the persistent pedicel. The absorbents of these blood-vessels now commence active operation and undermine the antler. They do not carry away the surface of the bone evenly so as to leave it smooth, but as it were they remove alternate particles, or rather alternate groups of granules, till the union, which before was so firm that no force could break it at the point of junction, has become so weakened that the antler drops off or is detached by some slight violence. This process of absorption requires about one month's time. As before stated the blood now flows freely from the blood-vessels of the periosteum of the pedicel which had penetrated the seam, now ruptured by the removal of the antler. If we now examine the butt of the antler we shall find the surface very rough, like coarse sand-paper, resulting from the unequal absorption before described.

We shall also find it of a most immaculate whiteness without the least trace of blood coming from it, although it is sometimes stained with the blood from below.

Space will not now permit me to pursue the subject and explain the peculiarities of the growth of the antlers on the emasculated buck, and show why it is that they never mature so as to be thrown off, but are persistent through a long course of years, even to the death of the animal.

REVIEWS AND BOOK NOTICES.

YOUNG'S PHYSICAL GEOGRAPHY.*—This is a terse and excellent compilation by one who, as formerly connected with the geological survey of Great Britain and now a teacher of geology, knows how to meet the wants of students. As the preface was written in November, 1873, and the latest information given concerning the results of deep sea dredging and other explorations which have thrown so much light on the geology of the globe, we may feel sure that it contains very late information. The views on the formation of continents and theoretical considerations regarding the geological cause of the present distribution of animals and

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* Physical Geography. By John Young, Regius Professor in the University of Glasgow. Putnam's advanced Science Series, New York. 12mo, pp. 368. [1874, no date on title page.] $1.00.